		closure. DCC gates are assumed to be closed during December 15 through January 31. February 1 through June 15, DCC gates are operated based on D-1641 requirements.
Suisun Marsh Salinity Control Gates	• No change. Gates will continue to be closed up to 20 days per year from October through May.	• For the DSM2 modeling, used generalized seasonal and tidal operations for the gates. • Seasonal operation: The radial gates are operational from October to February if Martinez electrical conductivity (EC) is higher than 20,000, and for remaining months they remain open. • Tidal operations when gates are operational: Gates close when: downstream channel flow is < 0.1 (onset of flood tide); Gates open when: upstream to downstream stage difference is greater than 0.3 ft (onset of ebb tide).
Export to inflow ratio	• Operational criteria are the same as defined under D-1641, and applied as a maximum 3-day running average. • The D-1641 export/inflow (E/I) ratio calculation was largely designed to protect fish from south Delta entrainment. For the PA, Reclamation and DWR propose that the NDD be excluded from the E/I ratio calculation. In other words, Sacramento River inflow is defined as flows downstream of the NDD and only south Delta exports are included for the export component of the criteria.	• Combined export rate is defined as the diversion rate of the Banks and Jones Pumping Plant (PP) from the south Delta channels. • Delta inflow is defined as the sum of the Sacramento River flow downstream of the proposed NDD, Yolo Bypass flow, Mokelumne River flow, Cosumnes River flow, Calaveras River flow, San Joaquin River flow at Vernalis, and other miscellaneous in-Delta flows.
[a] See CWF BA Table 3.3-2 for PA CalSim II Modeling Assumptions		

Table 6.1-3. PA CalSim II criteria and modeling assumptions.

Dual Conveyance Scenario with 9,000 cfs NDD (includes Intakes 2, 3 and 5 with a maximum diversion capacity of 3,000 cfs at each intake)

1. North Delta Diversion Bypass Flows
These parameters define the criteria for modeling purposes and provide the real-time operational criteria levels as operations move between and among the levels. Actual operations will be based on real-time monitoring of hydrologic conditions and fish presence/movement as described in CWF BA Section 3.3.3.1, *North Delta Diversions*.

<u>Low-Level Pumping (December-June)</u>
Diversions of up to 6% of total Sacramento River flow such that bypass flow never falls below 5,000 cfs. No more than 3,000 cfs can be diverted at any one intake.

<u>Initial Pulse Protection</u>
Low level pumping as described in CWF BA Table 3.3-1will be maintained through the initial pulse period. For modeling, the initiation of the pulse is defined by the following criteria: (1) Sacramento River flow at Wilkins Slough increasing by more than 45% within a five-day period, and (2) flow on the fifth day greater than 12,000 cfs.

The pulse (and low-level pumping) continues until either (1) Sacramento River flow at Wilkins Slough returns to pre-pulse flow level (flow on first day of pulse period), (2) Sacramento River flow at Wilkins Slough decreases for 5 consecutive days, or (3) Sacramento River flow at Wilkins Slough is greater than 20,000 cfs for 10 consecutive days.

After pulse period has ended, operations will return to the bypass flow table (Sub-Table A).

If the initial pulse period begins and ends before December 1st in the modeling, then any second pulse that may occur before the end of June will receive the same protection, *i.e.,* low level pumping as described in CWF BA Table 3.3-1.

<u>Post-Pulse Operations</u>
After initial pulse(s), allowable diversion will go to Level I Post-Pulse Operations (see Sub-Table A) until 15 total days of bypass flows above 20,000 cfs occur. Then allowable diversion will go to the Level II Post-Pulse Operations until 30 total days of bypass flows above 20,000 cfs occur. Then allowable diversion will go to the Level III Post-Pulse Operations.

Sub-Table A. Post-Pulse Operations for NDD Bypass Flows

Implement following bypass flow requirements sufficient to minimize any increase in the upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough, and (2) Sacramento River downstream of Georgiana Slough. These points are used to minimize any increase in upstream transport toward the proposed intakes or into Georgiana Slough. Allowable diversion will be greater of the low-level pumping or the diversion allowed by the following bypass flow rules.

Level I Post-Pulse Operations			**Level II Post-Pulse Operations**			**Level III Post Pulse Operations**		
If Sacramento River flow is over...	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**
December–April								
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining	5,000 cfs	11,000 cfs	Flows remaining	5,000 cfs	9,000 cfs	Flows remaining after constant

		after constant low level pumping			after constant low level pumping			low level pumping
15,000 cfs	17,000 cfs	15,000 cfs plus 80% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 60% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 50% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,600 cfs plus 60% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	13,400 cfs plus 50% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	12,000 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	18,400 cfs plus 30% of the amount over 20,000 cfs	20,000 cfs	no limit	15,900 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	13,000 cfs plus 0% of the amount over 20,000 cfs
May								
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping
15,000 cfs	17,000 cfs	15,000 cfs plus 70% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 50% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 40% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,400 cfs plus 50% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	13,000 cfs plus 35% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	11,400 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	17,900 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	14,750 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	12,400 cfs plus 0% of the amount over 20,000 cfs

June								
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping
15,000 cfs	17,000 cfs	15,000 cfs plus 60% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 40% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 30% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,200 cfs plus 40% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	12,600 cfs plus 20% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	10,800 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	17,400 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	13,600 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	11,800 cfs plus 0% of the amount over 20,000 cfs
Bypass flow requirements in other months:								
If Sacramento River flow is over...			**But not over...**			**The bypass is...**		
July–September								
0 cfs			5,000 cfs			100% of the amount over 0 cfs		
5,000 cfs			No limit			A minimum of 5,000 cfs		
October–November								
0 cfs			7,000 cfs			100% of the amount over 0 cfs		
7,000 cfs			No limit			A minimum of 7,000 cfs		

2. South Delta Channel Flows

<u>OMR Flows</u>

All of the baseline model logic and input used in the NAA as a surrogate for the OMR criteria required by the various fish protection triggers (density, calendar, turbidity and flow based triggers) described in the 2008 Service and the 2009 NMFS BiOps were incorporated into the modeling of the PA except for NMFS BiOp Action IV.2.1 – San Joaquin River inflow/export (I/E) ratio. The PA includes the proposed operational criteria, as well. Whenever the BiOps' triggers require OMR be less negative or more positive than those shown below, those OMR requirements will be met. These newly proposed OMR criteria (and associated HORG operations) are in response to expected changes under the PA, and only applicable after the proposed NDD becomes operational. Until the NDD becomes operational, only the OMR criteria under the 2008 Service and 2009 NMFS BiOps apply to CVP and SWP operations.

Combined OMR flows must be no less than values below[a] (cfs)

(WY type classification based Sacramento River 40-30-30 index)

Month	W	AN	BN	D	C
Jan	0	-3,500	-4,000	-5,000	-5,000
Feb	0	-3,500	-4,000	-4,000	-4,000
Mar	0	0	-3,500	-3,500	-3,000
Apr	varies[b]	varies[b]	varies[b]	varies[b]	varies[b]
May	varies[b]	varies[b]	varies[b]	varies[b]	varies[b]
Jun	varies[b]	varies[b]	varies[b]	varies[b]	varies[b]
Jul	N/A	N/A	N/A	N/A	N/A
Aug	N/A	N/A	N/A	N/A	N/A
Sep	N/A	N/A	N/A	N/A	N/A
Oct	varies[c]	varies[c]	varies[c]	varies[c]	varies[c]
Nov	varies[c]	varies[c]	varies[c]	varies[c]	varies[c]
Dec	-5,000[d]	-5,000[d]	-5,000[d]	-5,000[d]	-5,000[d]

[a] Values are monthly averages for use in modeling. The model compares these minimum allowable OMR values to 2008 Service BiOp RPA OMR requirements and uses the less negative flow requirement.

[b] Based on San Joaquin inflow relationship to OMR provided below in Sub-Table B.

[c] Two weeks before the D-1641 pulse (assumed to occur October 16-31 in the modeling), No OMR restrictions (for modeling purposes an OMR requirement of -5,000 cfs was assumed during this 2 week period).
Two weeks during the D-1641 pulse, no south Delta exports.
Two weeks after the D-1641 pulse, -5,000 cfs OMR requirement (through November).

[d] OMR restriction of -5,000 cfs for Sacramento River winter-run Chinook salmon when North Delta initial pulse flows are triggered or OMR restriction of -2,000 cfs for delta smelt when triggered. For modeling purposes (to compute a composite Dec allowable OMR), remaining days were assumed to have an allowable OMR of -8000 cfs.

Head of Old River Operable Gate Operations/Modeling assumptions (% OPEN)

MONTH	HORG[a]	MONTH	HORG[a]
Oct	50% (except during the pulse)[b]	May	50%
Nov	100% (except during the post-pulse period)[b]	Jun 1–15	50%
Dec	100%	Jun 16–30	100%
Jan	50%[c]	Jul	100%
Feb	50%	Aug	100%
Mar	50%	Sep	100%
April	50%		

[a] Percent of time the HORG is open. Agricultural barriers are in and operated consistent with current practices. HORG will be open 100% whenever flows are greater than 10,000 cfs at Vernalis.
HORG operation is triggered based upon SWRCB D-1641 pulse trigger. For modeling assumptions only, two weeks before the D-1641 pulse, it is assumed that the HORG will be open 50%.

[b] During the D-1641 pulse (assumed to occur October 16-31 in the modeling), it is assumed the HORG will be closed.
For two weeks following the D-1641 pulse, it was assumed that the HORG will be open 50%.
Exact timing of the action will be based on hydrologic conditions. See CWF BA Table 3.3-1 for HOR gate operations under the PA.

[c] The HORG becomes operational at 50% when salmon fry are migrating (based on real time monitoring). This generally occurs when flood flow releases are being made. For the purposes of modeling, it was assumed that salmon fry are migrating starting on January 1.

In the CalSim II modeling, the "HORG open percentage" specified above is modeled as the percent of time within a month that HORG is open. In the Delta Simulation Model II (DSM2) modeling, HORG is assumed to operate such that the above-specified percent of "the flow that would have entered the Old River if the HORG were fully open" would enter the Old River.

Sub-Table B. San Joaquin Inflow Relationship to OMR			
April and May		**June**	
If San Joaquin flow at Vernalis is the following	Average OMR flows would be at least the following (interpolated linearly between values)	If San Joaquin flow at Vernalis is the following	Average OMR flows would be at least the following (no interpolation)
≤ 5,000 cfs	-2,000 cfs	≤ 3,500 cfs	-3,500 cfs
6,000 cfs	+1,000 cfs	3,501 to 10,000 cfs	0 cfs
10,000 cfs	+2,000 cfs		
15,000 cfs	+3,000 cfs	10,001 to 15,000 cfs	+1,000 cfs
≥30,000 cfs	+6,000 cfs	>15,000 cfs	+2,000 cfs

3. Delta Cross Channel Gate Operations

Assumptions

Per SWRCB D-1641 with additional days closed from October 1 – January 31 based on 2009 NMFS BiOp Action IV.1.2 (closed during flushing flows from October 1 – December 14 unless adverse water quality conditions). This criterion is consistent with the NAA.

4. Rio Vista Minimum Instream Flows

Assumptions

September–December: Per D-1641; January-August: Minimum of 3,000 cfs.

5. Delta Outflow

Delta Outflow

SWRCB D-1641 requirements, or outflow per requirements noted below, whichever is greater.

Months	Delta Outflow Requirement
Spring (Mar–May):	Additional spring outflow requirement
Fall (September–November):	Implement 2008 Service BiOp Fall X2 requirement

Notes: Protective outflows from March through May every year shall be determined by the use of a lookup table derived from a linear relationship between the 50% exceedance forecast for the current month's 8RI and recent historic Delta outflow (1980 – 2016). Operators shall utilize Net Delta Outflow Index (NDOI) data to confirm that the average Delta outflow target was met during each 30 day period from March – May. Operators shall provide daily NDOI data quantifying daily Delta outflow in each 30 day period to CDFW on or before April 20, May 21, and June 20 every year. Reduction in exports down to minimum health and safety requirements established in D-1641 (currently 1,500 cfs) may be necessary. These targets are intended to be provided through the acquisition of water from willing sellers and through operations of the CVP and SWP. Operators shall achieve Delta outflow targets through shared export allocations between the NDD and south Delta. If the target average Delta outflow is greater than 44,500 cfs operators shall consult with CDFW to determine how to allocate exports between the NDD and the south Delta.

Spring Outflow Criteria

As a condition of the 2081(b) ITP, CDFW is requiring DWR, upon initiation of the Test Period and throughout operation of the PA, to provide average Delta outflow for longfin smelt based on the 50% exceedance forecast of the current month's Eight River Index (8RI).

February ELT 8RI (TAF)	March 1 – March 15 Average Delta Outflow Target (cfs)	March ELT 8RI (TAF)	March 16 – April 15 Average Delta Outflow Target (cfs)	April ELT 8RI (TAF)	April 16 – May 15 Average Delta Outflow Target (cfs)	May ELT 8RI (TAF)	May 16 – May 31 Average Delta Outflow Target (cfs)
0	0	0	0	0	0	0	0
450	7100	450	7100	450	7100	250	4000
900	7100	1000	7100	1000	7100	850	4000

1000	9100	1625	7100	1500	7100	1545	4000
1100	11000	1700	8700	1855	7100	1600	4700
1200	13000	1800	10900	1900	8100	1700	6000
1300	14900	1900	13000	2000	10300	1800	7300
1400	16900	2000	15200	2100	12500	1900	8600
1500	18800	2100	17400	2200	14700	2000	9900
1600	20800	2200	19500	2300	16900	2100	11300
1700	22700	2300	21700	2400	19100	2200	12600
1800	24700	2400	23800	2500	21300	2300	13900
1900	26600	2500	26000	2600	23500	2400	15200
2000	28600	2600	28100	2700	25700	2500	16500
2100	30500	2700	30300	2800	27900	2600	17800
2200	32500	2800	32400	2900	30100	2700	19100
2300	34400	2900	34600	3000	32300	2800	20400
2400	36400	3000	36800	3100	34500	2900	21700
2500	38300	3100	38900	3200	36700	3000	23000
2600	40300	3200	41100	3300	38900	3100	24300
2700	42200	3300	43200	3400	41200	3200	25600
2815	44500	3360	44500	3500	43400	3300	26900
> 2815	44500	> 3360	44500	3550	44500	3400	28300
				> 3550	44500	3500	29600
						3600	30900
						3700	32200
						3800	33500
						3900	34800
						4000	36100
						4100	37400
						4200	38700
						4300	40000
						4400	41300
						4500	42600
						4600	44000
						4650	44500
						> 4650	44500

6. Operations for Delta Water Quality and Residence Time

Assumptions

July–September: Prefer south delta intake up to total pumping of 3,000 cfs; no specific intake preference beyond 3,000 cfs.

October–June: Prefer NDD (real-time operational flexibility).

7. In-Delta Agricultural and Municipal & Industrial Water Quality Requirements

Assumptions

Existing D-1641 agricultural and municipal & industrial (AG and MI) standards.

8. D-1641 E/I Ratio Computation

Assumptions

In computing the Delta E/I ratio in the CalSim II model, the NDD is not included in the export term, and the Sacramento River inflow is as modeled downstream of the NDD.

Pulse-Protection

- A fish pulse is defined as combined catch of X_p[12] winter-run and spring-run sized Chinook salmon in a single day at specified locations.
- Upon initiation of fish pulse, operations must reduce to low-level pumping.
- Pumping may not exceed low-level pumping for the duration of fish pulse. However, additional pumping above low-level may be allowed as long as a minimum of 35,000 cfs[13] bypass flow is maintained during the period of pulse protection. A fish pulse is considered over after X[14] consecutive days with daily combined catch of winter- and spring run-sized Chinook salmon less than X_p[14] at or just downstream of the new intakes.
- Post-pulse bypass flow operations will be determined through initial operating studies evaluating the level of protection provided at various levels of pumping.
- All subsequent pulses of winter- and spring-run Chinook salmon will be afforded the same level of protection as the first pulse (see Footnotes below).
- Unlimited fish pulses are protected in any given year.

Flow criteria are applied seasonally (month by month) and according to the following five WY types. Under the observed hydrologic conditions over the 82-year period (1922–2003), the number of years of each WY type is listed below. The WY type classification, unless otherwise noted, is based on the Sacramento Valley 40-30-30 WY Index defined under Revised D-1641.

- Wet (W) water-year: the wettest 26 years of the 82-year hydrologic data record, or 32% of years.
- Above-normal (AN) water-year: 12 years of 82, or 15%.

---

[12] Preliminary evaluation of the effects of the proposed operations will use triggers developed from data provided by existing monitoring stations. The values and monitoring location would depend upon operation of a new/additional station, the method used to identify winter- and spring-run Chinook salmon, collection of sufficient data, and the time of year. The PA includes a condition related to pulse protection which triggers a pulse based on a Knights Landing catch index (X_p) greater than or equal to 5 winter-run-sized and spring-run-sized fish.

[13] Preliminary evaluation of the effects of the proposed operations will use a minimum off-ramp bypass flow developed from existing data. The off-ramp bypass flow required will be determined based on pre-construction studies identified in CWF BA Section 3.4.7.3.

[14] Preliminary evaluation of the effects of the proposed operations will use triggers developed from data provided by existing monitoring stations. The values and monitoring location would depend upon operation of a new/additional station, the method used to identify winter- and spring-run Chinook salmon, collection of sufficient data, and the time of year. The PA includes a condition related to pulse protection which considers a pulse to be over when Knights Landing catch index (X_p) is less than 5 for a duration (X) of 5 days.

- Below-normal (BN) water-year: 14 years of 82, or 17%.
- Dry (D) water-year: 18 years of 82, or 22%.
- Critical (C) water-year: 12 years of 82, or 15%.

The above noted frequencies are expected to change slightly under projected climate conditions at year 2030. The number of years of each WY type per D-1641 Sacramento Valley 40-30-30 WY Index under the projected climate condition assumed for the CWF BA, over the 82-year period (1922–2003) is provided below. CWF BA Appendix 5.A, Section 5.A.3, *Climate Change and Sea Level Rise*, provides more information on the assumed climate change projection at year 2030.

- Wet WY: the wettest 26 years of the 82-year hydrologic data record, or 32% of years.
- Above-normal WY: 13 years of 82, or 16%.
- Below-normal WY: 11 years of 82, or 13%.
- Dry WY: 20 years of 82, or 24%.
- Critical WY: 12 years of 82, or 15%.

Refer to the CWF BA and appendices for further discussion of the operational criteria and assumptions, the RTO Decision-Making Process, the CSAMP, and future drought procedures.

Table 6.1-4. Modeled March longfin smelt outflow criteria: Monthly Net Delta Outflow Index in relation to Eight River Index.

Eight River Index[15] (March), TAF	Monthly Net Delta Outflow Index (March), cfs
0	0
545	6,200
1,488	8,800
1,911	12,700
2,140	17,100
2,421	20,000
2,575	25,200
3,104	35,000
3,492	43,700
≥4,217	44,500
Note: Net Delta Outflow Index targets are linearly interpolated for 8RI values falling between those shown on the table. This approach is based on the 90% forecast.	

Maintenance of the Facilities

The PA includes the maintenance of the proposed NDD, tunnels, IF, CCF and Pumping Plant, connections to Banks and Jones Pumping Plants, power supply and grid connections, HORG, and the south Delta facilities. Refer to the *BiOp Resolution Log* for additional detail on the frequency of the maintenance activities.

---

[15] The 8RI refers to the sum of the unimpaired runoff for the following locations: Sacramento River flow at Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River flow at Smartville; American River, total inflow to Folsom Reservoir; Stanislaus River, total inflow to New Melones Reservoir; Tuolumne River, total inflow to Don Pedro Reservoir; Merced River, total inflow to Exchequer Reservoir; and San Joaquin River, total inflow to Millerton Lake.

North Delta Diversions

CWF BA Appendix 3.B, *Conceptual Engineering Report, Volume 1,* Section 6.3, *Maintenance Considerations*, discusses maintenance needs at the NDD intakes. These include intake dewatering, sediment removal, debris removal, control of biofouling, corrosion, and equipment needs.

Intake Dewatering

The intake structure on the land side of each screen bay group (*i.e.*, a group of 6 fish screens) will be dewatered by closing the slide gates on the back wall of the intake structure, installing bulkheads into guides at the front of the structure, and pumping out the water with a submersible pump; see CWF BA Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Drawings 15, 16, 17, 19, and 22, for illustrations of this structure. The intake collector box conduits can be dewatered by closing the gates on either side of the conduits and pumping out the water between the gates. Dewatering may occur to remove accumulated sediment (described below) or to repair the fish screens.

The water removed for intake maintenance would likely be disposed by discharge to the conveyance tunnels. Any discharge to surface water (the Sacramento River) would occur in accordance with the terms and conditions of a valid National Pollutant Discharge Elimination System (NPDES) permit and any other applicable Central Valley Regional Water Quality Control Board (CVRWQCB) requirements.

Sediment Removal

Maintenance sediment removal activities include activities that will occur on both the river side and land side of the fish screens. Anticipated maintenance activities include suction dredging around the intake structure, and mechanical excavation around intake structures using track-mounted equipment and a clamshell dragline. Mechanical excavation will occur behind a floating turbidity control curtain. These maintenance activities will occur on an approximately annual basis, depending upon the rates of sediment accumulation.

Sediment will also be annually dredged from within the sedimentation basins using a barge mounted suction dredge, and will periodically be removed from other piping and conduits within the facility by dewatering them. Lastly, sediment will be annually removed from the sediment drying lagoons using equipment such as a front-end loader. The accumulated sediment will be tested and disposed in accordance with the materials reuse provisions of AMM6.

Maintenance dredging will occur only during DWR's proposed in-water work windows. Subsequent regulatory authorizations for the dredging work typically include a permit for in-water work from the Corps and a water quality certification from the CVRWQCB.

Debris Removal

After high-to-extreme flow conditions, the intake structures will be visually inspected for debris. If a large amount of debris has accumulated, the debris must be removed. The intake screens will be maintained by continuous traveling cleaning mechanisms, or other screen cleaning technology. Cleaning frequency will depend on the debris load.

A log boom system will be aligned within the river alongside the intake structure to protect the fish screens and fish screen cleaning systems from being damaged by large floating debris. Spare parts for vulnerable portions of the intake structure will be housed onsite to minimize downtime, should repairs be needed.

Biofouling

Biofouling, the accumulation of algae and other sessile biological organisms, could occlude the fish screens and impair function. A key design provision for intake facilities is that all mechanical elements can be moved to the water surface for inspection, cleaning, and repairs. The intake facilities will have top-side gantry crane systems for removal and insertion of screen panels, and tuning baffle assemblies and bulkheads. All panels will require periodic removal for pressure washing. Additionally, screen bay groups will require periodic dewatering (as described above) for inspection and assessment of biofouling rates. With the prospective invasion of quagga and zebra mussels into inland waters, screen and bay washing could become more frequent. Coatings and other deterrents to reduce the need for such maintenance will be investigated during further facility design. In-water work is not expected to be necessary to address biofouling, as the potentially affected equipment is designed for ready removal from the water as described above. However, if needed, in-water work would be performed consistent with DWR's proposed in-water work windows.

Corrosion

Materials for the intake screens and baffles will consist of plastics and austenitic stainless steels. Other systems will be constructed of mild steel, provided with protective coatings to preserve the condition of those buried and submerged metals and thereby extend their service lives. Passive (galvanic) anode systems can also be used for submerged steel elements. Maintenance consists of repainting coated surfaces and replacing sacrificial (zinc) anodes at multi-year intervals.

Equipment Needs

Operation and maintenance equipment for the intake facilities include the following: (1) a self-contained portable high-pressure washer unit to clean fish screen and solid panels, concrete surfaces, and other surfaces, (2) submersible pumps for dewatering, (3) a floating work platform for accessing, inspecting, and maintaining the river side of the facility, (4) a hydraulic suction dredge, and (5) a man basket or bridge inspection rig to safely access the front of the intake structure from the upper deck.

Sedimentation Basins and Drying Lagoons

The sedimentation system at each intake will consist of a jetting system in the intake structure that will resuspend accumulated river sediment through the box conduits to two unlined earthen sedimentation basins where it will settle out, and then on to four drying lagoons (CWF BA Appendix 3.C, *Conceptual Engineering Report, Volume 2,* Sheets 10-13, 18-21, and 28-30; see also Appendix 3.B, *Conceptual Engineering Report, Volume 1,* Section 6.1.2, *Sedimentation System General Arrangement*, for detailed description of the sedimentation system). Sediment particles larger than 0.002 mm are expected to be retained (settle out) in the sedimentation basins, while particles smaller than 0.002 mm (*i.e.*, colloidal particles) will flow through to the tunnel system to the IF.

At each intake, a barge-mounted suction dredge will hydraulically dredge the sedimentation basins through a dedicated dredge discharge pipeline to 4 drying lagoons. Dredging will occur annually. Dredged material will be disposed at an approved upland site.

Tunnels

Maintenance requirements for the tunnels have not yet been finalized. Some of the critical considerations include evaluating whether the tunnels need to be taken out of service for inspection and, if so, how frequently. Typically, new water conveyance tunnels are inspected at least every 10 years for the first 50 years and more frequently thereafter. In addition, the equipment that the facility owner must put into the tunnel for maintenance needs to be assessed so that the size of the tunnel access structures can be finalized. Equipment such as trolleys, boats, harnesses, camera equipment, and communication equipment will need to be described prior to finalizing shaft design, as will ventilation requirements. As described above, it is anticipated that, following construction, large-diameter construction shafts will be modified to approximately 20-ft diameter access shafts.

Intermediate Forebay

The IF embankments will be maintained to control vegetation and rodents. Embankments will be repaired when they show signs of erosion. Maintenance of control structures could include repairs to roller gates, radial gates, and stop logs. Maintenance requirements for the spillway will include the removal and disposal of any debris blocking the outlet culverts.

The majority of easily settled sediments are removed at the sedimentation basins at each intake facility. The IF provides additional opportunity to settle sediment. It is anticipated that over a 50-year period, sediments will accumulate to a depth of approximately 4.1 ft, which is less than one-half the height of the overflow weir at the outlet of the IF. Thus maintenance dredging of the IF is not expected to be necessary at the time of this consultation.

Clifton Court Forebay and Pumping Plant

The existing CCF is proposed to be expanded and partitioned into a North Clifton Court Forebay (NCCF) and South Clifton Court Forebay (SCCF). The NCCF and SCCF embankments and grounds, including the area around the consolidated pumping plants, will all be maintained to control vegetation and rodents. They will also be subject to embankment repairs in the event of erosion. Maintenance of forebay control structures could include repairs to roller gates, radial gates, and stop logs. Maintenance requirements for the spillway will include the removal and disposal of any debris blocking the structure. Riprap slope protection on the water-sides of the embankments will require periodic maintenance to monitor and repair any sloughing. In-water work, if needed (*e.g.*, to maintain riprap below the ordinary high-water mark), would be performed during DWR's proposed in-water work window.

The small fraction of sediment passing through the IF will be transported through the tunnels to NCCF. Given the upstream sediment removal and the large storage available in the forebay, sediment accumulation at NCCF is expected to be minimal over a 50-year period, and no maintenance dredging is expected to be needed during the life of the facility.

Connections to Banks and Jones Pumping Plants

Maintenance requirements for the canal will include erosion control, control of vegetation and rodents, embankment repairs in the event of erosion, and monitoring of seepage flows. Sediment traps may be constructed by deepening portions of the channel upstream of the structures where the flow rate will be reduced to allow suspended sediment to settle at a controlled location. The sediment traps will be periodically dredged to remove the trapped sediment.

Power Supply and Grid Connections

Three utility grids could supply power to the PA conveyance facilities: Pacific Gas and Electric Company (PG&E) (under the control of the California Independent System Operator), the Western Area Power Administration (Western), and/or the Sacramento Municipal Utility District (SMUD). The electrical power needed for the conveyance facilities will be procured in time to support construction and operation of the facilities. Purchased energy may be supplied by existing generation, or by new generation constructed to support the overall energy portfolio requirements of the western electric grid. It is unlikely that any new generation will be constructed solely to provide power to the PA conveyance facilities. It is anticipated the providers of the three utility grids that supply power to the PA will continue to maintain their facilities.

Head of Old River Gate

For the operable barrier proposed under the PA, maintenance of the gates will occur every 5 to 10 years. Maintenance of the motors, compressors, and control systems will occur annually and require a service truck.

Each miter or radial gate bay will include stop log guides and pockets for stop log posts to facilitate the dewatering of individual bays for inspection and maintenance. Each gate bay will be inspected annually at the end of the wet season (April) for sediment accumulation. Maintenance dredging around the gate will be necessary to clear out sediment deposits. Dredging around the gates will be conducted using a sealed clamshell dredge. Depending on the rate of sedimentation, maintenance dredging is likely to occur at intervals of 3 to 5 years, removing no more than 25% of the original amount of sediment dredged from the Old River channel to build the structure. The timing and duration of maintenance dredging will comply with the proposed in-water work windows. Spoils will be dried in the areas adjacent to the gate site. A formal dredging plan with further details on specific maintenance dredging activities will be developed prior to dredging. Guidelines related to dredging are given in CWF BA Appendix 3.F, *General Avoidance and Minimization Measures,* AMM6, *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material.* AMM6 requires preparation of a sampling and analysis plan; compliance with relevant NPDES and SWRCB requirements; compliance with proposed in-water work windows; and other measures intended to minimize adverse effects to listed species.

Existing South Delta Export Facilities

The PA includes maintenance of CVP and SWP facilities in the south Delta after the proposed intakes become operational. Maintenance means those activities that maintain the capacity and operational features of the CVP and SWP water diversions and conveyance facilities. Maintenance activities include maintenance of electrical power supply facilities; maintenance as needed to ensure continued operations; replacement of facility or system components when necessary to maintain system capacity and operational capabilities; and upgrades and technological improvements of facilities to maintain system capacity and operational capabilities, improve system efficiencies, and reduce operations and maintenance costs.

Monitoring

Monitoring activities will occur prior to operations and after operations commence. Monitoring and studies of listed fish species will be focused on the effects of construction and operation of the dual conveyance facilities. This monitoring will begin with baseline data collection needed to compare to similar results post-construction. While a detailed effort has been made regarding proposed monitoring for the NDD, monitoring prior to operations will be required throughout the action area. DWR has committed to working with the Service and other agencies to develop the specifics (including timeframes) of monitoring using various technical teams. A Service-approved monitoring plan will be developed, and construction cannot begin until it has been approved by the Service.

Monitoring and studies related to operations that must occur after dual conveyance has commenced consist of four types: monitoring addressing the operation of the proposed new facilities, monitoring related to species condition and habitat that may be influenced by operations of the new facilities, monitoring to evaluate the effectiveness of the proposed facilities, and monitoring addressing the performance of the habitat protection and restoration sites.

If monitoring activities may affect listed species or critical habitat and are not subject to future section 7 consultation or approvals (*i.e.*, the Corps' Phase 1 permit), reinitiation of this consultation is required to address those effects. Monitoring activities associated with all other aspects of the PA will require future approvals and will be subject to future consultations if those activities may affect listed species or critical habitat.

Prior to Dual Conveyance Operations

Monitoring and studies related to operation of the proposed new facilities, that must occur prior to operation of the new facilities, is focused on the conveyance facilities and their potential effects on listed fish species. This monitoring begins with gathering baseline data to compare with post-construction monitoring and studies. A more detailed effort has already been made regarding monitoring for the NDD. DWR has committed to working with the Service, NMFS, and CDFW to develop the specifics of that monitoring, which will be a key charge of both the CCF Technical Team and HORG Technical Team.

For the NDD, specific monitoring studies will be developed in collaboration with the Service, NMFS, and CDFW that are focused on preconstruction conditions and on design of the diversions. These monitoring efforts prior to operations will build off the work done by the FFTT (FFTT 2011), which identified monitoring associated with the NDD and their effects. The preconstruction studies identified by this group were focused on specific key questions rather than general monitoring needs and are listed in Table 6.1-5. Monitoring studies focused on the NDD were developed during the BDCP process and include items 7 and 8 as listed in Table 6.1-6. These studies and their projected timeframes will be revisited as the final monitoring plan is developed.

Table 6.1-5. Preconstruction studies at the North Delta Diversions.

Potential Research Action[1]	Key Uncertainty Addressed	Timeframe
1. This action includes preconstruction study 1, *Site Locations Lab Study*, as described by the Fish Facilities Working Team (FFWT 2013). The purpose of this study is to develop physical hydraulic models to optimize hydraulics and sediment transport at the selected diversion sites.	What is the relationship between proposed north Delta intake design features and expected intake performance relative to minimization of entrainment and impingement risks?	Ten months to perform study; must be complete prior to final intake design.
2. This action includes preconstruction study 2, *Site Locations Numerical Study*, as described by the Fish Facilities Working Team (FWTT 2013). The purpose of this study is to develop site-specific numerical studies (mathematical models) to characterize the tidal and river hydraulics and the interaction with the intakes under all proposed design operating conditions.	How do tides and diversion rates affect flow conditions at the north Delta intake screens and at the Georgiana Slough junction?	Eight months to perform study; must be complete prior to final intake design.

3. This action includes preconstruction study 3, *Refugia Lab Study*, as described by the Fish Facilities Working Team (FFWT 2013). The purpose of this study is to test and optimize the final recommendations for fish refugia that will be incorporated in the design of the NDD.	How should north Delta intake refugia be designed in principle to achieve desired biological function?	Nine months to perform study; must be complete prior to final intake design.
4. This action includes preconstruction study 4, *Refugia Field Study*, as described by the Fish Facilities Working Team (FFWT 2013). The purpose of this study is to evaluate the effectiveness of using refugia as part of NDD design for the purpose of providing areas for juvenile fish passing the screen to hold and recover from swimming fatigue and to avoid exposure to predatory fish.	How do alternative NDD refugia designs perform with regard to desired biological function?	Two years to perform study; must be complete prior to final intake design.
5. This action includes preconstruction study 5, *Predator Habitat Locations*, as described by the Fish Facilities Working Team (FFWT 2013). The purpose of this study is to perform field evaluation of similar facilities (*e.g.*, Freeport, RD108, Sutter Mutual, Patterson Irrigation District, and Glenn Colusa Irrigation District) and identify predator habitat areas at those facilities.	Where is predation likely to occur near the new NDD?	One to two years to perform study; must be complete prior to final intake design.
6. This action includes preconstruction study 6, *Baseline Fish Surveys*, as described by the Fish Facilities Working Team (FFWT 2013), somewhat modified based on discussions with NMFS during 2014. The purpose of this study is to perform literature search and potentially field evaluations at similar facilities (*e.g.*, Freeport, RD108, Sutter Mutual, Patterson Irrigation District, and Glenn Colusa Irrigation District), to determine if these techniques also take listed species of fish, and to assess ways to reduce such by-catch, if necessary.	What are the best predator reduction techniques, *i.e.*, which techniques are feasible, most effective, and best minimize potential impacts on listed species?	Two years to perform study; must be complete prior to final intake design.
7. This action includes preconstruction study 7, *Flow Profiling Field Study*, as described by the Fish Facilities Working Team (FFWT 2013). The purpose of this study is to characterize the water velocity distribution at river transects within the proposed diversion reaches for differing flow conditions. Water velocity distributions in intake reaches will identify how hydraulics change with flow rate and tidal cycle, and this information will be used in fish screen final design and in model-based testing of fish screen performance (preconstruction study 8, below).	What is the water velocity distribution at river transects within the proposed intake reaches, for differing river flow conditions?	One year to perform study; must be complete prior to final intake design.
8. This action includes preconstruction study 8, *Deep Water Screens Study*, as described by the Fish Facilities Working Team (FFWT 2013). The purpose of this study is to use a computational fluid dynamics model to identify the hydraulic characteristics of deep fish screen panels.	What are the effects of fish screens on hydraulic performance?	Nine months to perform study; must be complete prior to final intake design.
9. This action includes preconstruction study 9, *Predator Density and Distribution*, as described by the Fish Facilities Working Team (FFWT 2013); and includes post-construction study 9, *Predator Density and Distribution*, as described by the FFTT (FFTT 2011). The purpose of this study is to use an appropriate technology (to be identified in the detailed study plan) at two to three proposed screen	What are predator density and distribution in the NDD reaches of the Sacramento river?	Start in 2016 to collect multiple annual datasets before construction begins. The post-construction

locations; the study will also perform velocity evaluation of eddy zones, if needed. The study will also collect baseline predator density and location data prior to facility operations, compare that to density and location of predators near the operational facility; and identify ways to reduce predation at the facilities.		study will cover at least 3 years, sampling during varied river flows and diversion rates.
10. This action includes preconstruction study 10, *Reach-Specific Baseline Juvenile Salmonid Survival Rates*, as described by the Fish Facilities Working Team (FFWT 2013); and includes post-construction study 10, *Post-Construction Juvenile Salmon Survival Rates*, as described by the FFTT (FFTT 2011). The purpose of this study is to determine baseline rates of survival for juvenile Chinook salmon and steelhead within the Sacramento River near proposed NDD sites for comparison to post-project survival in the same area, with sufficient statistical power to detect a 5% difference in survival. Following initiation of project operations, the study will continue, using the same methodology and same locations. The study will identify the change in survival rates due to construction/operation of the intakes.	How will the new NDD affect survival of juvenile salmonids in the affected reach of the Sacramento River?	The preconstruction study will cover at least 3 years and must be completed before construction begins. The post-construction study will cover at least 3 years, sampling during varied river flows and diversion rates.
11. This action includes preconstruction study 11, *Baseline Fish Surveys*, as described by the Fish Facilities Working Team (FFWT 2013) and includes post-construction study 11, *Post-Construction Fish Surveys*, as described by the Fish Facilities Technical Team (FFTT 2011). The purpose of this study is to determine baseline densities and seasonal and geographic distribution of all life stages of delta and longfin smelt inhabiting reaches of the lower Sacramento River where the NDD will be sited. Following initiation of diversion operations, the study will continue sampling using the same methods and at the same locations. The results will be compared to baseline catch data to identify potential changes due to intake operations.	How will the new NDD affect delta and longfin smelt density and distribution in the affected reach of the Sacramento River?	Preconstruction study will cover at least 3 years. Post-construction study will be performed for duration of project operations (or delisting of species), with timing and frequency to be determined.
Notes [1] All research actions listed in this table are part of the PA. For all proposed research actions, a detailed study design must be developed prior to implementation. The study design must be reviewed and approved by CDFW, NMFS, and the Service prior to implementation.		

Table 6.1-6. Monitoring actions for listed species of fish for the North Delta Diversions.

Monitoring Action(s)	Action Description[1]	Timing and Duration
1. Fish screen hydraulic effectiveness	This action includes post-construction study 2, *Long-term Hydraulic Screen Evaluations*, combined with post-construction study 4, *Velocity Measurement Evaluations*, as described by the Fish Facilities Technical Team (FFTT 2011). The purpose of this monitoring is to confirm screen operation produces approach and sweeping velocities consistent with design criteria, and to measure flow velocities within constructed refugia. Results of this monitoring will be used to "tune" baffles and other components of the screen system to consistently achieve compliance with design criteria.	Approximately 6 months beginning with initial facility operations.

2. Fish screen cleaning	This action includes post-construction study 3, *Periodic Visual Inspections*, as described by the Fish Facilities Technical Team (FFTT 2011). The purpose of this monitoring is to perform visual inspections to evaluate screen integrity and the effectiveness of the cleaning mechanism, and to determine whether cleaning mechanism is effective at protecting the structural integrity of the screen and maintaining uniform flow distribution through the screen. Results of this monitoring will be used to adjust cleaning intervals as needed to meet requirements.	Initial study to occur during first year of facility operation with periodic re-evaluation over life of project.
3. Refugia effectiveness	This action includes post-construction study 5, *Refugia Effectiveness*, as described by the FFTT (FFTT 2011). The purpose is to monitor refugia to evaluate their effectiveness relative to design expectations. This includes evaluating refugia operation at a range of river stages and with regard to effects on target species or agreed proxies. Results of this monitoring will be used to "tune" the screen system to consistently achieve compliance with design criteria.	Approximately 6 months beginning with initial facility operations.
4. Fish screen biological effectiveness	This action includes post-construction study 7, *Evaluation of Screen Impingement*, as described by the FFTT (FFTT 2011). The purpose of this monitoring is to observe fish activity at the screen face (using technology to be identified in the detailed study plan) and use an appropriate methodology (to be identified in the detailed study plan) to evaluate impingement injury rate. Results of this monitoring are to be used to assess facility performance relative to take allowances, and otherwise as deemed useful via the collaborative adaptive management process.	Study to be performed at varied river stages and diversion rates, during first 2 years of facility operation.
5. Fish screen entrainment	This action includes post-construction study 8, *Screen Entrainment*, as described by the FFTT (FFTT 2011). The purpose of this monitoring is to measure entrainment rates at screens using fyke nets located behind screens, and to identify the species and size of entrained organisms. Results of this monitoring are to be used to assess facility performance relative to take allowances, and otherwise as deemed useful via the collaborative adaptive management process.	Study to be performed at varied river stages and diversion rates, during first 2 years of facility operation.
6. Fish screen calibration	Perform hydraulic field evaluations to measure velocities over a designated grid in front of each screen panel. This monitoring will be conducted at diversion rates close to maximum diversion rate. Results of this monitoring will be used to set initial baffle positions and confirm compliance with design criteria.	Initial studies require approximately 3 months beginning with initial facility operations.
7. Fish screen construction	Document NDD design and construction compliance with fish screen design criteria (note, this is simple compliance monitoring).	Prior to construction and as-built.
8. Operations independent measurement	Document NDD compliance with operational criteria, with reference to existing environmental monitoring programs including (1) Interagency Ecological Program Environmental Monitoring Program: Continuous Multi-parameter Monitoring, Discrete Physical/Chemical Water Quality Sampling, (2) Reclamation and DWR: Continuous Recorder Sites, (3) CVRWQCB: NPDES Self- Monitoring Program, and (4) U.S. Geological Survey Delta Flows Network and National Water	Start prior to construction of water diversion facilities and continue for the duration of the PA.

	Quality Assessment Program. The purpose of this monitoring is to ensure compliance and consistency with other relevant monitoring programs, and to ensure that this information is provided to CDFW, NMFS, and the Service in association with other monitoring reporting.	
9. Operations measurement and modeling	Document NDD compliance with the operational criteria using flow monitoring and models implemented by DWR. The purpose of this monitoring is to ensure and demonstrate that the intakes are operated consistent with authorized flow criteria.	Start prior to completion of water diversion facilities and continue for the duration of the permit term.
10. North Delta intake reach salmonid survivorship	Determine the overall impact on survival of juvenile salmonids through the diversion reach, related to the operation of the new north Delta intakes. Use mark/recapture and acoustic telemetry studies (or other technology to be identified in the detailed study plan) to evaluate effects of facility operations on juvenile salmonids, under various pumping rates and flow conditions. Results of this monitoring are to be used to assess whether survival objectives for juvenile salmonids traversing the diversion reach are being met, to determine whether take allowances are exceeded, and otherwise as deemed useful via the collaborative adaptive management process.	Study to be performed at varied river flows and diversion rates, during first 2 to 5 years of facility operation.
Notes [1] All monitoring actions are part of the PA. For all proposed monitoring actions, a detailed study design must be developed prior to implementation. The study design must be reviewed and approved by CDFW, NMFS, and the Service prior to implementation.		

Monitoring after Dual Conveyance Operations Commence

Monitoring and studies related to CVP and SWP Delta operations, that must occur after operation of the new facilities has commenced, broadly consists of four types of monitoring, performed to assess system state and effects on listed species: monitoring addressing the operation of the proposed new facilities, monitoring related to species condition and habitat that may be influenced by operations of the new facilities, monitoring to evaluate the effectiveness of the proposed facilities, and monitoring addressing the habitat protection and restoration sites.

6.2 Standard (Non-programmatic) Actions

As stated in the *Consultation Approach* section above, some of the project elements are not subject to subsequent consultation and, therefore, must be addressed under standard (non-programmatic) consultation in this BiOp. Effects and any "reasonably certain to occur" incidental take are addressed in this BiOp. Additionally, sections *9.2.4 Project-level Reinitiation Triggers and Programmatic Approach with Subsequent Consultation* and the species-specific *Reinitiation Triggers* sections describes some additional specific conditions under which consultation will need to be reinitiated.

Geotechnical Explorations

DWR will perform a series of geotechnical investigations along the selected water conveyance alignment, at locations proposed for facilities, and at material borrow areas. The proposed exploration is designed as a two-part program (referred to as Phases 2a and 2b) to collect geotechnical data. The land-based portion will occur at approximately 1,380 locations and will be active for a period ranging from a few hours to 12 work days per site, depending on exploration type and target depth. The overwater portion will occur at approximately 90 to 100 locations. DWR will conduct overwater drilling only during August 1 through October 31 depending on location and will only work between the hours of sunrise and sunset. Duration of drilling at each location will vary depending on the number and depth of the holes, drill rate, and weather conditions, but activities are not expected to exceed 60 days at any one location. Total duration for land-based explorations will require approximately 24 months and will typically occur from April through November. Total duration of overwater explorations will require approximately 14 months, using two drill rigs operating concurrently for 6 days per week from June through November depending on location. The schedule for geotechnical explorations is not included in CWF BA Appendix 3.D, *Construction Schedule for the Proposed Action*.

Refer to Section 3.2.1 of the CWF BA for DWR's description of the geotechnical explorations. Section 3.2.1 references CWF BA Appendix 3.G, *Geotechnical Exploration Plan—Phase 2*, a draft 2014 document for DHCCP.

Conveyance Tunnels

Design

The conveyance tunnels will extend from the proposed intake facilities to the NCCF. The tunneled conveyance includes the north tunnels, which consist of three reaches that connect the intakes to the IF; and two parallel main tunnels, connecting the IF to the NCCF. Final surface conveyance connecting the NCCF to the existing export facilities is described in Section 3.2.6, *Connections to the Banks and Jones Pumping Plants*, of the CWF BA. The water conveyance tunnels will be operated with a gravity feed system, delivering to a pumping station located at the NCCF.

Each tunnel segment will be excavated by a tunnel boring machine (TBM), which is a very large and heavy electrically-powered machine that will be launched from the bottom of a launch shaft, and will tunnel continuously underground to a reception shaft. For a detailed explanation of the tunneling work, see the CWF BA Appendix 3.B, *Conceptual Engineering Report, Volume 1,* Sections 3.1, *Proposed Alignment and Key Components*, 3.2, *Reach Descriptions*, and 11.0, *Tunnels;* Sections 11.2.5, *Tunnel Excavation Methods*, and 11.2.6, *Tunnel Support*, in particular, detail the process of tunneling. The cutterhead of the TBM will be hydrostatically isolated from the remainder of the machine, so that the inside of the tunnel will be dry and at atmospheric pressure. As the TBM proceeds, precast concrete tunnel lining sections will be assembled within the TBM to produce a rigid, watertight tunnel lining. Typically very little dewatering will be needed to keep the interior of the tunnel dry. An electrically-powered conveyor will carry excavated material from the TBM back to the launch shaft, where a vertical conveyor will carry the material to the surface for disposal. A narrow-gauge railway may be installed in the tunnel with a diesel locomotive, or rubber wheeled diesel engine trucks may be used to carry workers, tunnel lining segments, and other materials from the launch shaft to the TBM.

The TBM launch facilities will be relatively large and active construction sites because they are continuously active during a TBM tunnel drive, as they will provide the only surface access to the tunnel. Thus they will require stockpiles of materials used by the TBM. They will provide access to the TBM for its operation and maintenance, and will receive all materials excavated by the TBM. Conversely, TBM reception facilities will be used to recover the TBM at the end of its drive, and these will have smaller footprints and a more limited operating scope than the launch facilities. Table 6.2-1 summarizes all of the proposed tunnel drives, identifying launch and reception shafts, tunnel lengths, and tunnel diameters. CWF BA Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Figure 11-1, shows this information on a map. Note that Bouldin Island and the IF will be the primary tunneling launch sites (Table 6.2-1).

Refer to the map book for the tunnel drives presented in the CWF BA Appendix 3.A, *Map Book for the Proposed Action*. Design drawings showing tunnel routing, design of the shaft structures, and layout of the surface facilities at launch and reception sites appear in CWF BA Appendix 3.C, *Conceptual Engineering Report, Volume 2*; see Drawings 44 to 54, showing the tunnel routing and all associated areas of surface activity. A detailed project schedule, showing periods of tunneling and associated activities, is given in CWF BA Appendix 3.D, *Construction Schedule for the Proposed Action*. Each TBM launch or retrieval shaft will require barge access for equipment and materials. AMMs to be implemented during construction work at all surface facilities supporting the tunneling work appear in CWF BA Appendix 3.F, *General Avoidance and Minimization Measures*.

Table 6.2-1. Tunnel drive summary.

Reach	Launch Shaft	Reception Shaft	Inside Diameter (ft)	Length (miles)
1	Intake 2	Intake 3 junction structure	28	1.99
2	IF inlet	Intake 3 junction structure	40	6.74
3	IF inlet	Intake 5	28	4.77
4 (west tunnel)	IF	Staten Island	40	9.17
4 (east tunnel)	IF	Staten Island	40	9.17
5 (west tunnel)	Bouldin Island	Staten Island	40	3.83
5 (east tunnel)	Bouldin Island	Staten Island	40	3.83
6 (west tunnel)	Bouldin Island	Bacon Island	40	8.86
6 (east tunnel)	Bouldin Island	Bacon Island	40	8.86
7 (west tunnel)	NCCF	Bacon Island	40	8.29
7 (east tunnel)	NCCF	Bacon Island	40	8.29

Tunnel Construction Components

Shaft Site Facilities

Facilities at launch shaft sites will include a concrete batch plant and construction work areas including offices, parking, shop, short-term segment storage, fan line storage, crane, dry houses, settling ponds, daily spoils piles, temporary reusable tunnel material (RTM) storage, electrical power supplies, air, water treatment, and other requirements. There will also be space for slurry ponds at sites where slurry wall construction is required. Work areas for RTM handling and permanent spoils disposal will also be necessary. Facilities at reception shafts will be similar but more limited, as there will be no need for a concrete batch plant or for RTM storage.

Shaft Site Preparation

Shaft site preparation is detailed in CWF BA Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Section 11.2.1, *Advance Works Contracts*. During shaft site preparation, vehicular access will be established and electrical service will be provided via temporary transmission line. The shafts will be located on pads elevated to above the 200-year flood elevation; fill will be placed to construct these pads. The site will be fenced for security and made ready for full construction mobilization. Due to the pervasive nature of these activities, all surface disturbance associated with construction at each shaft site will occur very early during the period of activity at each site; the entire site footprint will be disturbed and will remain so for the duration of construction.

The number of shafts that will be required is not known precisely at this time (Table 6.2-2). Final determination of the number and siting of shaft locations will depend upon determinations by the tunnel construction contractor(s). Table 6.2-2 shows the number of safe haven interventions expected to be associated with each tunnel, based upon current understanding of site conditions.

Access Routes

Access routes for each shaft site are shown in CWF BA Appendix 3.A, *Map Book for the Proposed Action*, and in CWF BA Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Drawings 44 to 54. These sources also depict the footprint for new permanent access roads, which will be a feature of every shaft site. SR 160 provides access to the intakes and their associated shafts, but for all other shafts (including atmospheric safe haven access shafts), access roads will be constructed. Those roads will be permanent features except at atmospheric safe haven access shafts, where they will be temporary.

Fill Pads

Permanent conveyance facilities (intakes, permanent shaft sites, IF, and CCF facilities) will require fill pads with a top surface elevation of approximately 25 ft to 35 ft, depending upon location (CWF BA 2016, Appendix 3.B, Table 3-4). These sites are currently near or below sea level, so substantial fill material volumes will be needed and will be sourced by borrow sites, the placement of which will cause consolidation settlement of underlying delta soils at the construction sites. The shafts at the IF are an exception; these will initially be constructed at near existing site grades, and final site grades will be established in conjunction with final IF inlet and outlet facilities. The permanent elevated pad perimeters are assumed to extend to 75 ft from the outside of the shafts to facilitate heavy equipment access for maintenance and inspection. As the existing ground elevations are significantly lower than the final planned elevations, the pad fills will slope down to the adjacent existing site grades at an inclination of between 3 horizontal to 1 vertical (3H to 1V) to 5H to 1V.

Due to the soft ground conditions expected at the construction sites, it will also be necessary to improve existing sites to support heavy construction equipment, switchyards, transformers, concrete and grout plants, cranes and hoists, TBMs, and water treatment plants.

Pad construction will precede other work at the shaft site; at the IF, for instance, earthwork will begin 2.5 years prior to a 9-month period of ground improvement before the sites will be ready for mobilization of construction equipment needed to build the pads.

Shaft Construction

Shaft construction procedures are described in CWF BA Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Section 11.2.3, *Shaft Construction*. Shafts are circular in plan with a 100-ft diameter for 28-ft tunnels and a 113-ft diameter for 40-ft tunnels. These are minimum sizes; larger diameter shafts may be needed to launch and retrieve the TBM from the bottom of the shaft.

Final design of shafts is not complete, but the basic objective is to use concrete construction methods to create a watertight shaft sufficiently strong to resist the hydrostatic pressure created by tunneling down into the Delta sediments. This will be done by constructing a concrete cylinder prior to removing the sediment from the shafts. Potential construction methods include overlapping concrete caisson walls, panel walls, jet-grout column walls, secant piles walls, slurry walls, precast sunken caissons, and potentially other technologies. In the areas where TBMs enter and exit, a special break-in/break-out section will be constructed as an integral part of the shaft.

Shaft bottoms will be stabilized to resist uplift associated with external hydrostatic pressure, during both excavation and operation. It may be necessary to pretreat the ground at the shaft area from the surface to the bottom of the shaft to control blowouts during excavation of the shaft. Concrete working slabs capable of withstanding uplift will be required at all shaft locations to provide a stable bottom and a suitable working environment. To place the bottom slab, the shaft will be excavated to approximately 30 to 50 ft below the invert level of the tunnel, and a concrete base will be placed underwater using tremie techniques. It is expected that this base will be a large concrete plug to withstand ground water pressure, with optional relief wells to relieve uplift pressure during tunnel construction. Large openings need to be created in the shaft walls to launch and retrieve the TBMs. To maintain structural stability around the launch and retrieval openings, it will be necessary to provide additional structural support (*e.g.*, reinforced concrete buttresses or frame structures within the shaft). Dewatering will be required during shaft construction and operation. Dewatering of sediments surrounding the shaft may be needed during construction, depending upon the construction method selected. Dewatering will also be needed during excavation within the shaft, following placement of the tremie seal, and continuously thereafter until the shaft is completely constructed.

<u>Tunnel Excavation</u>

The tunnel excavation procedure is described in CWF BA Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Sections 11.2.5, *Tunnel Excavation Methods*, to 11.2.8, *Logistics*. Tunnel excavation will occur entirely underground and thus will entail no surface impacts, apart from those associated with the TBM launch and reception shafts and the construction access shafts. Tunnel dewatering needs will be minor, compared to those associated with shaft construction.

<u>Intermediate Tunnel Access</u>

In the event that maintenance, inspection, or repair of the TBM cutterhead is needed, contractors will be able to access their equipment either from inside the TBM or from the surface using construction access shafts. Such access points are termed "safe havens" because they constitute points where humans can work on the outside of the TBM in conditions of comparative safety.

Access to the cutterhead from inside the TBM will occur at a "pressurized safe haven intervention." Pressurized safe haven interventions will be constructed by injecting grout from the surface to a point in front of the TBM, or by using other ground improvement techniques such as ground freezing. Once the ground has been stabilized by one of these techniques, the

TBM will then bore into the treated area. Surface equipment required to construct the safe haven intervention site will include a small drill rig and grout mixing and injection equipment, and facilities to control runoff from dewatering. Disturbance at the site is expected to be limited to an area of approximately 100 ft by 100 ft. The surface drilling and treatment operation will typically take about 8 weeks to complete. Once complete, all equipment will be removed and the surface features reestablished. To the greatest extent possible, established roadways will be used to access the intervention sites. If access is not readily available, temporary access roads will be built.

Access to the cutterhead from the surface, referred to as an "atmospheric safe haven interventions," will require construction of a shaft. These construction access shafts will not require pad construction to elevate the top of the shaft to above the 200-year flood level. At these sites, a shaft roughly equal to the diameter of the TBM cutterhead will be excavated to tunnel depth. Approximately 3 acres will be required at each of these locations to set up equipment, construct flood protection facilities, excavate/construct the shafts, and set up and maintain the equipment necessary for the TBM maintenance work. It is anticipated that all work associated with developing and maintaining these shafts will occur over approximately 9 to 12 months. At the completion of the TBM maintenance at these sites, the TBM will mine forward, and the shaft location will be backfilled. Dewatering at construction access shafts may be required. Drilling muds or other materials required for drilling and grouting will be confined on the work site and such materials will be disposed of off-site at a permitted facility. Disturbed areas will be returned to preconstruction conditions by grading and appropriate revegetation.

Table 6.2-2. Expected safe haven interventions.

Reach	Length (miles)	Number of Safe Haven Interventions	
		Pressurized	Atmospheric
1	1.99	1	1
2	6.74	5	1 to 3
3	4.77	3	1 to 2
4 (twin tunnel)	9.17	7	1 to 4
5 (twin tunnel)	3.83	2	1
6 (twin tunnel)	8.86	7	1 to 4
7 (twin tunnel)	8.29	6	1 to 3

The tunnel construction timeline is presented in CWF BA Appendix 3.D, *Construction Schedule for the Proposed Action*. The TBM launch shafts will be most active, producing RTM on a nearly continuous basis, for the following time periods:

- CCF: May 2020 to February 2025
- Bouldin Island: October 2020 to May 2025
- IF: May 2021 to October 2026
- Intake 2: October 2021 to July 2025

Overall, the peak period of activity will be from October 2020 to April 2025. Considering the time required to prepare each site, as well as time required to stabilize and restore RTM storage areas, each site will remain active throughout essentially the whole period of construction (2018 to 2030). Since the CCF, IF, and Intake 2 are essential components of the conveyance system, these sites will remain permanently active. The Bouldin Island site, however, will close following revegetation and restoration for the RTM storage areas; only a small permanent tunnel access shaft will remain.

During mobilization, construction personnel, stockpiles of materials, and needed equipment will be stationed at the construction sites. The construction phase at both permanent and temporary shaft sites will conclude with landscaping and the installation of safety lighting and security fencing.

Intermediate Forebay

The IF, located on Glanville Tract, will receive water from the three NDD and discharge it to the twin tunneled conveyance to CCF. The IF will store water between the proposed intake and conveyance facilities and the main tunnel conveyance segment.

The IF will provide an atmospheric break in the deep tunnel system and act as a buffer for CVP and SWP exports between the NDD and the Banks Pumping Plant. This buffer provides make-up water and storage volume to mitigate transient interruptions in water diversions resulting from planned or unplanned adjustments of system pumping rates. The IF also facilitates isolating segments of the tunnel system, while maintaining operational flexibility. Thus each tunnel, into and out of the IF, can be hydraulically isolated for maintenance, while maintaining partial system capacity.

Design

CWF BA Appendix 3.A, *Map Book for the Proposed Action*, Sheet 5, shows the IF, access routes, and related facilities in the area. CWF BA Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Drawings 55 to 68, show an artist's concept of the completed forebay, as well as drawings showing the complete forebay and various design details. CWF BA Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Section 14, *Forebays*, provides detail on the design, construction and operations of the IF; see particularly Sections 14.1. (description and site plan), 14.2. (construction methodology), 14.2.4 (embankment completion), 14.2.6 (spillway), and 14.2.8 (inlet and outlet structures). CWF BA Section 5.3.1, *Intermediate Forebay Size Evaluation*, describes the basis for design sizing of the IF.

The IF will have a capacity of 750 acre feet (af) and an embankment crest elevation of +32.2 ft, which meets DHCCP flood protection standards (*i.e.*, a 200-year flood with provision for sea level rise). Current ground surface elevation at the site averages +0 ft. The water surface elevation (WSE) varies between a maximum elevation of +25 ft and a minimum elevation of -20 ft. The IF will include an emergency spillway and emergency inundation area to prevent the forebay from overtopping. This spillway will divert water during high flow periods to an approximately 131-acre emergency inundation area adjacent to and surrounding the IF. From the IF, water will be conveyed by a gravity bypass system through an outlet control structure into a dual-bore 40-ft-diameter tunnel that runs south to the CCF. The IF will serve to enhance water supply operational flexibility by using forebay storage capacity to regulate flows from the intakes to the CCF. The IF footprint will have a water surface area of 54 acres at maximum water elevation.

Construction

Construction of the IF entails first excavating the embankment areas down to suitable material (Table 6.2-3). A slurry cutoff wall is then placed to a depth of -50 ft to eliminate the potential for piping or seepage beneath the embankment. The embankment is then constructed of compacted fill material. Inlet and outlet shafts (which also serve as TBM launch shafts) will then be constructed. Next, the interior basin will be excavated to design depth (-20 ft), and the spillway will be constructed. All excavations are expected to require dewatering, and dewatering is expected to be continuous throughout construction of the IF. Ground improvement may be needed beneath structures, depending upon the outcomes of the geotechnical explorations.

The IF will have a surface footprint of 243 acres, all of which is permanent (under 2016 conditions, the area is a vineyard). Approximately 1 million cubic yards (cy) of excavation and 2.3 million cy of fill material will be required to complete the IF embankments. Much of the excavated material is expected to be high in organics and unsuitable for use in embankment construction and will therefore require off-site disposal. However, fill material may be sourced onsite from locations within the permanent impact footprint. Material sourced from off-site will be obtained as described in the Borrow Fill section of the CWF BA. The construction phase at the IF will conclude with landscaping and the installation of safety lighting and security fencing.

Table 6.2-3. Summary construction schedule for the Intermediate Forebay.

Description	Start[a]	End[a]	Duration
Contract management, supervision, administration, temporary facility operations, and delivery of construction supplies	7/1/2026	7/11/2031	61 months
Earthworks	7/1/2026	12/25/2029	42 months
Inlet & outlet ground improvements	12/28/2028	10/12/2030	23 months
Inlet & outlet site work	9/27/2029	4/12/2030	8 months
Operate concrete batch plant; inlet & outlet concrete work	3/27/2030	4/11/2031	13 months
Inlet & outlet gates, mechanical & electrical work	12/25/2030	7/11/2031	7 months

[a] Dates given in this table assume a Record of Decision date of 1/1/2018 and a construction end date of 7/11/2031.

Clifton Court Forebay

<u>Design</u>

In the CWF BA, DWR recognizes that design of the modifications and expansion of CCF are in early stages. As such, DWR proposes to convene a CCF Technical Team upon initiation of formal consultation for the PA and will meet periodically until DWR completes final design for the proposed CCF modifications (a time period expected to be at least two years). The general concepts and construction components are summarized below and reference the CWF BA where appropriate.

The CCF will be divided into two separate but contiguous forebays: NCCF and SCCF. The NCCF will receive screened water from the new Sacramento River intakes while the SCCF will continue to receive flows from the existing Old River intake gate. The NCCF will be sized to meet the hydraulic needs of balancing water entry from the NDD with discharge via the CVP and SWP export pumps. The SCCF will continue to meet the needs of SWP export pumps taking in south Delta water; as such it will function as a replacement for the current CCF, and thus must be enlarged to the south in order to maintain its current size while still accommodating the creation of the NCCF. SCCF will consist of the southern portion of the existing CCF, with expansion to the south into Byron Tract 2.

The CCF will be expanded by approximately 590 acres to the southeast. The existing CCF will be dredged, and the expansion area excavated, to design depths of -8 ft for the NCCF and -10 ft for the SCCF. A new embankment will be constructed around the perimeter of the entire forebay complex, and another embankment will separate the NCCF from the SCCF. The tunnels from the Sacramento River intakes will enter the Clifton Court Pumping Plant (CCPP) at the northeastern end of the NCCF, immediately south of Victoria Island, and flows will typically be pumped into the NCCF.

An emergency spillway will be constructed in the NCCF east side embankment, south of the CCPP fill pad. The spillway will be sized to carry emergency overflow (9,000 cfs, the maximum inflow from the NDD) to the Old River, so a containment area will not be necessary. The shallow foundation beneath this structure must be improved to prevent it from failing. The ground improvement will be to elevation -50.0 ft both within the footprint of the structure and beyond it by a distance of approximately 25 ft. The work will be performed within the sheet pile installed to build the in-water portion of the eastern embankment.

Detailed information on design of the proposed facilities at CCF is given in CWF BA Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Sections 4.4.6, *Clifton Court Forebay Pump Plant (CCFPP) Operations*; 4.4.7, *North Clifton Court Forebay Operations*. Section 7, *CCF Pumping Plant*, describes the design and construction of the CCF pumping plant, while the north and south CCF and their construction methodology are described in Sections 14.1.2, *North Clifton Court Forebay*; 14.1.3, *South Clifton Court Forebay*; 14.2.2, *General Excavation for the NCCF and SCCF*; 14.2.3, *General Excavation for the Existing South Embankment of Clifton*

Court Forebay; 14.2.5, *New Clifton Court Forebay Embankment*; 14.2.6, *New Spillway and Stilling Basin*; and 14.2.8, *New Forebay Structures*.

Per the CWF BA, Appendix 3.A, *Map Book for the Proposed Action*, Sheet 13, shows the CCF, access routes, and related facilities in the area. CWF BA Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Drawing 2, provides an overview of the CCF facilities in relation to the rest of the conveyance facilities, and Drawing 54 provides a site-scale view of the proposed facilities at CCF. Drawing 74 shows an artist's concept of the completed CCF pumping plant, and Drawings 75 to 78 show details of the proposed pumping plant. Drawing 82 is a detailed overall CCF site plan, and Drawings 85 to 87 provide sectional views of the proposed embankments that contain the CCF. Drawings 90 and 91 provide plan and section views of the proposed spillway from the NCCF into Old River.

The NCCF will be designed to accommodate hydraulic surges and transitions related to short-term (typically less than 24 hours) differences in the rate of water delivery to NCCF and the rate of export by the CVP and SWP pumps. The NCCF will also be the site for a pump station, the operations of which form the primary control and constraints on the rate of water diversion through the NDD intakes (although that rate is also subject to control at the river intakes). Collective operations of these facilities will be coordinated through an operations center sited at the NCCF pump station. The SCCF will continue to operate as under current conditions. The proposed size of the CCF and its appurtenant facilities have been optimized consistent with the overall design goal of the PA to achieve diversion rates at the NDD not exceeding 9,000 cfs, and to achieve overall CVP and SWP water export rates consistent with existing authorizations for those facilities, subject to operational and regulatory constraints detailed in Section 3.3, *Operations and Maintenance of the New and Existing Facilities*.

<u>Construction</u>

Due to the duration and complexity of the proposed work at CCF, a phased work schedule is planned and described further in the CWF BA and *BiOp Resolution Log*. The phases include the following activities:

- Construct embankment needed for forebay expansion on the south in the dry.
- Construct sheet pile channel in existing Clifton Court south embankment.
- Remove existing embankment on the south.
- Install sheet piles required for construction during the proposed in-water work window.
- Dewater and complete fish salvage operation in the CCF north cell. Prior to the start of construction, a fish salvage plan will be prepared in coordination with the State and Federal fisheries agencies.
- Construct divider embankment between CCF north cell and south cell.
- Continue construction activities in the CCF north cell in the dry.
- Dredge the central part of CCF south cell between the divider wall and the existing south embankment. Dredging activities in the CCF south cell will be limited to the in-water work window and are expected to continue for up to five years.

- Construct remainder of the CCF south cell embankments on the east and west.

The overall schedule for activities at CCF is shown in the *BiOp Resolution Log and* CWF BA Appendix 3.D, *Construction Schedule for the Proposed Action*; see drawings in CWF BA Appendix 3.C, *Conceptual Engineering Report, Volume 2*, for locations of the referenced structures. Four major elements of the proposed construction will occur in the CCF area: tunneling, the construction of a CCPP, the modifications to the current CCF to create the NCCF and SCCF, and connections to the Banks and Jones pumping plants.

- Tunneling (Reach 7) will start from the CCPP construction site and will excavate north to Bacon Island, as described in CWF BA Section 3.2.3, *Tunneled Conveyance*; RTM from the tunnels will be disposed near CCF as described in Section 3.2.10.6, *Dispose Spoils*. Tunneling activity will begin 47 months after project start (scheduled to occur in January; the start year depends upon the date of project authorization and the time needed to prepare contract specifications and issue contracts) and will proceed continuously for 61 months.
- The CCPP will be constructed at the northeast corner of the CCF complex and includes the shafts used to launch the TBMs. Construction will start at the CCPP beginning 36 months after project start and will proceed continuously for 100 months.
- CCF work will occur throughout the site, and will be continuously active from 84 months after project start for 63 months, for an expected completion at 147 months after project start. Apart from startup activities (access improvement, mobilization, etc.), embankment and canal work will continue from 90 months to 130 months after project start. Work on control structures and spillways will take 36 months, occurring from 108 months to 144 months after project start.

Clifton Court Pumping Plant

Design

Each of the two units at CCPP will have a design pumping capacity of 4,500 cfs and will include 4 large pumps (1,125 cfs capacity) and 2 smaller pumps (563 cfs capacity). One large pump at each plant will be a spare. Each pumping plant will be housed within a building and will have an associated electrical building. The pumping plant buildings will be circular structures with a diameter of 182 ft and each will be equipped with a bridge crane that will rotate around the building and allow for access to the main floor for pump removal and installation. The total site for the pumping plants, electrical buildings, substation, spillway, access roads, and construction staging areas is approximately 95 acres. The main floor of the pumping plants and appurtenant permanent facilities will be constructed at a minimum elevation of 25 ft to provide flood protection. The bottom of the pump shafts will be at an elevation of approximately -163 ft, though a concrete base slab, shaft lining, and diaphragm wall will be constructed to deeper levels (to an elevation of -275 ft). A control room within an electrical building at the pumping facility site will be responsible for controlling and monitoring the communication between the intakes, pumping plants, and the Delta Field Division Operations and Maintenance Center, DWR Headquarters, and the Joint Operations Center.

The CCPP shafts will be larger in inside diameter (150 ft instead of 113 ft) than most shafts serving 40-ft tunnel bores due to the design needs of the pumping plant. As shown in CWF BA Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Drawings 75 and 76, the appurtenant facilities will be more extensive than at most tunnel shaft sites, including a permanent electrical substation, two electrical buildings, and an office/storage building, as well as temporary facilities for storage, staging, construction electrical, and water treatment (for stormwater). All of these facilities will be sited on the CCF embankment, at the design flood elevation (*i.e.*, a 200-year flood with provision for sea level rise) of 25 ft.

A 230 kilovolt (kV) transmission line and associated 230Kv–115kV substation used during construction will be repurposed and used to power the pumping plants at the CCF location. The repurposed substation will provide power to a new substation that will convert power from 115kV to 13.8kV. This substation will then include 13.8 kV feeder lines to a proposed electrical building to distribute the power to the major loads including the main pumps, dewatering pumps, and 13.8kV to 480V transformers.

<u>Clifton Court Pumping Plant Construction Components</u>

A detailed account of CCPP construction appears in CWF BA Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Section 7.2, *Construction Methodology*.

<u>Site Access</u>

Vehicular site access during construction will use existing roads: from the east, from Byron Highway via Clifton Court Road and the Italian Slough levee crest road or the NCCF embankment crest road. Access from the south will be from the Byron Highway via NCCF embankment crest road and West Canal levee crest road. Barge access will also be needed, for transport of heavy TBM sections and other very large equipment and materials, and possibly for transport of bulk materials (fill material or excavated material). Barge access will be from the West Canal using a proposed barge unloading facility.

<u>Cofferdam and Fill Work</u>

A sheet pile cofferdam will be placed to enclose the portion of the CCPP fill pad adjoined by water (CWF BA Appendix 3.C, *Conceptual Engineering Report, Volume 2,* Drawings 75 and 83). Note that, the design has been modified to dewater NCCF prior to CCPP construction. Thus, no sheet pile cofferdam will be placed in the portions of the CCPP fill pad adjoining the NCCF. Sheet pile placement for cofferdam installation will be performed by a barge-mounted crane and/or a crane mounted on the existing levee, equipped with vibratory and impact pile driving rigs. Fill pad construction will then proceed within the dewatered area, including fill placement, compaction, and ground improvement.

Dewatering

Extensive dewatering will be required during construction of the CCPP shafts.

Connections to Banks and Jones Pumping Plants

Construction at CCF will also include connections to the existing Banks and Jones pumping plants. The new system configuration will allow both the Banks PP and the Jones PP to draw water from existing sources and from the NCCF.

The new system configuration will require canals and control structures and two new siphons, shown in CWF BA Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Sheets 83 and 84. One siphon will convey NCCF water beneath the SCCF outlet canal. The second siphon will convey NCCF water to the Banks PP underneath the Byron Highway and the adjacent Southern Pacific Railroad line. Each siphon will have a control structure fitted with radial gates at the inlet, to regulate upstream WSE and flow through the siphons. In order to isolate a siphon for repairs and inspections, stop logs will also be provided at the downstream end of the siphon barrel. Control structures, fitted with radial gates, will also be located at the end of the new approach channels to control the amount of flow delivered to Jones PP and Banks PP. Refer to the CWF BA for further description and construction details for the canals, siphons and control structures.

Power Supply and Grid Connections

During construction, the PA will rely primarily upon electrical power sourced from the grid via temporary transmission lines to serve the TBMs and other project components. Use of diesel generators or other portable electrical power sources will be minimized due to the adverse air quality impacts of onsite power generation. Once operational, the largest power consumption will be for the pumping plant at CCF, where a grid connection will be available nearby. The intakes and IF will have relatively low operational power demands, which will be met via relatively short and lower-voltage connections to nearby grid sources.

Electric power will be required for intakes, pumping plants, operable barriers, boat locks, and gate control structures throughout the proposed conveyance alignment. Temporary power will also be required during construction of water conveyance facilities. New temporary electrical transmission lines to power construction activities will be built prior to construction of permanent transmission lines to power conveyance facilities. These lines will extend existing power infrastructure (lines and substations) to construction areas, generally providing electrical capacity of 12 kV at work sites. Main shafts for the construction of deep tunnel segments will require the construction of 69 kV temporary electrical transmission lines. Both temporary and permanent electrical transmission lines serving the PA are shown in CWF BA Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Sheet 94. Temporary and permanent transmission lines are also shown in the map book, CWF BA Appendix 3.A, *Map Book for the Proposed Action*, Sheets 1 to 15.

Transmission lines to construct and operate the water conveyance facilities will connect to the existing grid in two different locations. The northern point of interconnection will be located north of Lambert Road and west of Highway 99 (CWF BA Appendix 3.A, *Map Book for the Proposed Action*, Sheet 4). From here, a new 230 kV transmission line will run west, along Lambert Road, where one segment will run south to the IF on Glanville Tract, and one segment will run north to connect to a substation where 69 kV lines will connect to the three Sacramento River intakes. At the southern end of the conveyance alignment, the point of interconnection will be in one of two possible locations: southeast of Brentwood near Brentwood Boulevard (CWF BA Appendix 3.A, Sheet 15) or adjacent to the Jones Pumping Plant (CWF BA Appendix 3.A, Sheet 13). A 230 kV line will extend from one of these locations to a tunnel shaft northwest of CCF, and will then continue north, following tunnel shaft locations, to Bouldin Island. Lower voltage lines (CWF BA Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Sheet 94) will be used to power intermediate and reception shaft sites between the main drive shafts. Because the power required during operation of the water conveyance facilities will be much less than that required during construction, and because it will largely be limited to the pumping plants, all of the new electrical transmission lines between the IF and the CCF will be temporary.

An existing 500kV line, which crosses the area proposed for expansion of the CCF, will be relocated to the southern end of the expanded forebay in order to avoid disruption of existing power facilities. No interconnection to this existing line is proposed.

Temporary substations will be constructed at each intake, at the IF, and at each of the launch shaft locations. To serve permanent pumping loads, a permanent substation will be constructed adjacent to the pumping plants at CCF, where electrical power will be transformed from 230 kV to appropriate voltages for the pumps and other facilities at the pumping plant site. For operation of the three intake facilities and IF, existing distribution lines will be used to power gate operations, lighting, and auxiliary equipment at these facilities.

Utility interconnections are planned for completion in time to support most construction activities, but for some activities that need to occur early in the construction sequence (*e.g.*, constructing raised pads at shaft locations and excavating the shafts), onsite generation may be required on an interim basis. As soon as the connection to associated utility grid power is completed, electricity from the interim onsite generators will no longer be used.
Temporary lines will be constructed from existing facilities to each worksite where power will be necessary for construction. Construction of new transmission lines will require three phases: site preparation, tower or pole construction, and line stringing. For 12 kV and 69 kV lines, cranes will be used during the line stringing phase. For stringing transmission lines between 230 kV towers, cranes and helicopters will be used. Helicopters may fly as low as the top of the transmission towers, which may be as low as 60 feet. They will take-off and land in the right of ways obtained for transmission line construction, within the corridor identified on the construction footprint, or on other property obtained for the project, and identified on the project construction footprint, or designated existing helicopter pads (airstrips). They will not be allowed to land in sensitive habitat.

Construction of 230 kV and 69 kV transmission lines will require a corridor width of 100 ft and, at each tower or pole, a 100- by 50-ft area will be required for construction laydown, trailers, and trucks. Towers or poles will be located at intervals of 450 ft for 69kV lines (*i.e.*, 11 to 12 towers per mile), and 750 ft for 230kV lines (*i.e.*, 7 towers per mile). Construction will also require about 350 ft along the corridor (measured from the base of the tower or pole) at conductor pulling locations, which includes any turns greater than 15 degrees and/or every 2 miles of line. Construction will also require vehicular access to each tower or pole location. Vehicular access routes have not yet been determined.

For construction of 12 kV lines (when not sharing a 69 kV line), a corridor width of 25 to 40 ft will be necessary along the entire span, with a 50-ft width (25 ft in each direction) required at each pole. The construction of the pulling locations will require additional space; 200 ft along the corridor itself (measured from the base of the pole) and an additional 50-ft-wide area at conductor pulling locations. For a pole-mounted 12 kV/480 volt transformer, the work area will only be that normally used by a utility to service the pole (typically about 20 by 30 ft adjacent to pole). For pad-mounted transformers, the work area will be approximately 20 by 30 ft adjacent to the pad (for construction vehicle access). Construction of 12kV lines will also require vehicular access to each tower or pole location and routes have not yet been determined.

Temporary Access and Work Areas

Temporary access and work areas are defined for this project as areas or structures that will be removed, and not the duration of the activity. Construction work areas for the conveyance facilities will include areas for construction equipment and worker parking, field offices, a warehouse, maintenance shops, equipment and materials laydown and storage, and stockpiled topsoil strippings saved for reuse in landscaping.

Surface vehicular access will be needed for construction of all water conveyance facilities. Geotechnical exploration sites on water or on agricultural lands can be accessed by suitable vehicles, but all other construction sites will require road access. All-weather roads (asphalt paved) will be needed for year-round construction at all facilities, while dry-weather roads (minimum 12 inch thick gravel or asphalt paved) can be used for construction activities restricted to the dry season. Heavy construction equipment, such as diesel-powered dozers, excavators, rollers, dump trucks, fuel trucks, and water trucks will be used during excavation, grading, and construction of access/haul roads. Detour roads will be needed for all intakes and for traffic circulation around the work areas. Temporary barge unloading facilities will be constructed, used, and decommissioned.

Temporary concrete batch plants will be needed due to the large amount of concrete required for construction and the schedule demands of the PA. A temporary batch plant is proposed for each TBM launch shaft and TBM retrieval shaft location. Since there is no TBM launch shaft or TBM retrieval shaft at the site of the HORG, no concrete batch plant will be sited at the HORG. The area required for these plants will be within the construction footprint for these facilities but precise facility siting within the construction site has not yet been determined. Other facilities to be co-located with concrete batch plants within the construction site footprints will include fuel stations, pug mills, soil mixing facilities, cement storage, and fine and coarse aggregate storage. Fuel stations will be needed for construction equipment. Pug mills will be needed for generating processed soil materials used at the various sites. Soil mixing facilities will be needed for some of the muck disposal and for ground improvement activities. Cement and required admixtures will be stored at each site to support concrete, slurry walls, ground improvement, soil mixing, and other similar needs. TBM launch sites may also contain facilities that produce precast tunnel segments. If constructed, these will be located adjacent to concrete plants, and will also be within the construction site footprint. It is likely that each precast segment plant would require approximately 10 acres for offices, concrete plant, materials storage, and casting facilities.

All storage and processing areas will be properly contained as required for environmental and regulatory compliance. In addition, work at all sites will be required to comply with terms of all applicable AMMs.

Common Construction-Related Activities

Clearing

Essentially all lands within the temporary and permanent impact footprint are assumed to be cleared; the only exceptions are lands that are underlain by a structure (TBM-excavated tunnels), or that are beneath a structure (electrical transmission line wires, between the towers), or that are underwater (in association with the Delta intakes, the CCF, the Banks and Jones connections, and the HORG). Grading will be performed where required by the project design. Clearing and grading will be performed using standard equipment such as bulldozers. Topsoil from cleared areas will be stockpiled and reused at the close of construction.

Site Work

Site work will occur within previously cleared areas. It will include construction of site access, establishment of stockpiles and staging and storage areas, site fencing, onsite electric (such as a substation), and erection of temporary construction buildings (primarily offices and storage). Equipment used during site work mainly will include large vehicles and vehicle-mounted equipment such as cranes, which have the potential to elevate noise and light levels. Performance of site work will entail the risk of spills associated with vehicles and with materials transport, and the potential for localized erosion or stormwater dispersal of fuel, motor oil, etc. leaked from equipment.

Ground Improvement

Ground improvement will occur within previously cleared areas. Ground improvement serves to improve existing substrates at a site so that they can bear heavy loads and otherwise support the design of the proposed construction. Activities performed in ground improvement will include drilling, and injection of materials. Ground improvement commonly will occur in association with grading and dewatering. Improved ground will remain in place for the duration of the PA and thereafter. Equipment used in ground improvement will include large vehicle-mounted drilling and injection equipment with potential to create noise and light comparable to other construction equipment. Performance of ground improvement will entail the risk of spills associated with vehicles and with materials transport.

Borrow Fill

The total amount of borrow material for engineered fill used in all aspects of the PA will be approximately 21 million cy (as bank cubic yards). This total amount will include approximately 3 million cy for tunnel shaft pads, 6.5 million cy for the CCF embankments, 2 million cy for the IF embankments, 6.7 million cy at the three intake sites (approximately 2 million cy each), and 2.6 million cy at the CCPP site. Source locations for this borrow material will generally be within the work area footprint shown in CWF BA Appendix 3.A, *Map Book for the Proposed Action*. CWF BA Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Section 21, *Borrow Sites*, describes the criteria for selection of borrow sites and identifies suitable geological materials that could be used as sources of borrow material. Apart from engineering specifications, the criteria for selection of borrow sites will include the following: (1) borrow material should not require post-excavation processing (other than wetting), (2) borrow material should be exposed at surface and require no, or very limited, overburden removal, and (3) borrow areas should be selected to minimize the impact or encroachment on existing surface and subsurface development and environmentally sensitive areas as much as possible.

Fill to Flood Height

Permanent levees, embankments, and fills on which structures are sited at the intakes, the IF, the CCPP, and the Banks and Jones connections, will be filled to the design flood height, which is the level of the 0.5% annual exceedance flood (*i.e.*, the 200-year flood), plus an 18-inch allowance for sea level rise. Since current ground elevations at most of the construction sites are at or slightly below sea level, substantial volumes of material will be needed to construct these fills, and the weight of this material will cause substantial compaction and settling in the underlying ground. Compaction and settling will be addressed by ground improvement and dewatering wells, which are used to reduce hydraulic pressure within the sediments and accelerate the rate of compaction.

Fills to flood height will occur at sites that have previously been cleared. The fill material will be sourced from borrow sites and transported using conventional earthmoving equipment, or possibly conveyors if the distances involved are short and are entirely within the area cleared for facility construction. Performance of this work will entail the risk of spills associated with vehicles and with materials transport, and the potential for erosion or stormwater effects associated with cleared areas.

Dispose Spoils

Spoils will include materials removed from the construction area and placed for nonstructural purposes. The principal sources of spoils will be materials removed during excavation of tunnels (RTM) and dredging of the CCF. Secondary sources will include structural excavations during facilities construction. Table 6.2-4 provides key construction information on spoils and reusable tunnel material storage.

RTM is the by-product of tunnel excavation using a TBM. The RTM will be a plasticized mix consisting of soil cuttings, air, water, and may also include soil conditioning agents. Soil conditioning agents such as foams, polymers, and bentonite may be used to make soils more suitable for excavation by a TBM. Soil conditioners are non-toxic and biodegradable. During tunnel construction the daily volume of RTM withdrawn at any one shaft location will vary, with an average volume of approximately 6,000 cubic yards per day. It is expected that the transport of the RTM out of the tunnels and to the RTM storage areas will be nearly continuous during mining or advancement of the TBM. The RTM will be carried on a conveyor belt from the TBM to the base of the launch shaft. The RTM will be withdrawn from the tunnel shaft with a vertical conveyor and placed directly into the RTM work area using another conveyor belt system. From the RTM work area, the RTM will be roughly segregated for transport to RTM storage and water treatment (if required) areas as appropriate. CWF BA Appendix 3.A, *Map Book for the Proposed Action*, Sheets 1–5 and 7–15 show conveyor belt and RTM storage area locations.

RTM must be dewatered in order to stabilize it for long-term placement in a storage area. Atmospheric drying by tilling and rotating the material, combined with subsurface collection of excess liquids will typically be sufficient to render the material dry and suitable for long-term storage or reuse. Leachate will drain from ponds to a leachate collection system, then be pumped to leachate treatment ponds for possible additional treatment. Disposal of the RTM decant liquids will require permitting in accordance with NPDES and Regional Water Quality Control Board regulations. A retaining dike and underdrain liquid collection system (composed of a berm of compacted soil, gravel and collection piping, as described below), will be built at each RTM storage area. The purpose of this berm and collection system will be to contain any liquid runoff from the drying material. The dewatering process will consist of surface evaporation and draining through a drainage blanket consisting of rock, gravel, or other porous drain material. The drainage system will be designed per applicable permit requirements. Treatment of liquids (primarily water) extracted from the material could be done in several ways, including conditioning, flocculation, settlement/sedimentation, and/or processing at a package treatment plant to ensure compliance with discharge requirements.

Designated spoils storage areas are shown in the map book, CWF BA Appendix 3.A, *Map Book for the Proposed Action*. RTM will be the largest source of this material, and disposition of that material will be, on an acreage basis, one of the largest impacts of the PA (see Table 6.2-5). Dredged material from the CCF will be the second largest source of spoils.

Table 6.2-4. Spoils and Reusable Tunnel Material storage: key construction information.

• Final locations for storage of spoils, RTM, and dredged material will be selected based on the guidelines presented in *AMM6 Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material* (CWF BA Appendix 3.F, *General Avoidance and Minimization Measures*). • Conventional earthmoving equipment, such as bulldozers and graders, would be used to place the spoil. Some spoil, with the exception of RTM, may be placed on the land-side toes of canal embankments and/or setback levees. • Spoils may temporarily be placed in borrow pits or temporary spoil laydown areas pending completion of embankment or levee construction. Borrow pits created for this project will be the preferred spoil location. • RTM that may have potential for re-use in the PA (such as levee reinforcement, embankment or fill construction) will be stockpiled. The process for testing and reuse of this material is described further in *AMM6 Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material* (CWF BA Appendix 3.F, *General Avoidance and Minimization Measures*). • A berm of compacted imported soil will be built around the perimeter of the RTM storage area to ensure containment. The berm will conform to Corps guidelines for levee design and construction. • RTM will be stacked to an average depth of 10 ft; precise stacking depth will vary across disposal sites. • Maximum capacity of RTM storage ponds will be less than 50 af. • RTM areas may be subdivided by a grid of interior earthen berms in RTM ponds for dewatering. • Dewatering will involve evaporation and a drainage blanket of 2 ft-thick pea gravel or similar material placed over an impervious liner. • Leachate will drain from ponds to a leachate collection system, then be pumped to leachate ponds for possible additional treatment. • Transfer of RTM solids to disposal areas may be handled by conveyor, wheeled haul equipment, or barges, at the contractor's discretion. • Where feasible, the invert of RTM ponds will be a minimum of 5 ft above seasonal high groundwater table. • An impervious liner will be placed on the invert and along interior slopes of berms, to prevent groundwater contamination. • RTM will not be compacted. • Spoil placed in disposal areas will be placed in 12-inch lifts, with nominal compaction. • The maximum height for placement of spoil is expected to be 6 ft above preconstruction grade (10 ft above preconstruction grade for sites adjacent to CCF), and have side slopes of 5H:1V or flatter. • After final grading of spoil is complete, the area will be restored based on site-specific conditions following project restoration guidelines.

Table 6.2-5. Spoils disposition, volumes and acreages.

Disposal Site	Volume (cy)	Disposal Area (acres)
RTM and dredged material disposal site near Intake 2	1,020,000	45.6
RTM disposal sites near IF	9,060,000	404.7
RTM disposal site on Bouldin Island	8,340,000	1,208.8
RTM and dredged material disposal sites near CCF	5,370,000 (RTM) 7,000,000 (dredged)	899.6
TOTAL	**30,790,000**	**2,558.7**

RTM is expected to be reusable tunnel material, suitable as engineered fill for varied applications, and also suitable for restoration work such as tidal habitat restoration. However, end uses for that material have not yet been identified. It is likely that the material will remain in designated storage areas for a period of years before a suitable end use is identified, and any such use will be subject to environmental evaluation and permitting independent of the PA. Therefore disposition of RTM is assumed to be permanent, and future reuse of this material is not part of the PA.

Materials removed during surface excavation and dredging, or from clearing of the sedimentation basins, may also be reusable. As with RTM, no end uses for this material have yet been identified, such use is not part of the PA, and the material will be permanently disposed in the designated RTM and dredged material storage areas. The exception to this statement is topsoil removed during clearing for construction. Topsoil is not classified as spoils; it will be stockpiled and reused for landscaping and restoration.

Dewatering

Due to the generally high groundwater table in the Delta, the location of much of the construction alignment at below-sea-level elevations, and the extensive construction of below-grade structures, dewatering will be needed for nearly all components of conveyance construction. “Dewatering” as used in this document refers to the removal of water from a work area or from excavated materials, and discharge of the removed water to surface waters in accordance with the terms and conditions of a valid NPDES permit and any other applicable CVRWQCB requirements.

Dewatering will generally be accomplished using electrically powered pumps, which will either dewater via groundwater wells (thereby drawing down the water table to minimize the amount of water entering a work area) or by direct removal of water from an excavation or other work area (such as pumping water out of a cofferdam or the bottom of a tunnel access shaft). Dewatering of excavated materials would be accomplished in a similar manner, by stockpiling the material and allowing the water to infiltrate to an impervious layer such as a liner or the bottom of a storage tank, and then pumping or draining it prior to treatment or discharge. At most conveyance facilities, dewatering will be an ongoing activity throughout most of the period of construction activity.

The water removed during dewatering is subject to contamination. These waters will be stored in sedimentation tanks; tested for contaminants and treated in accordance with permit requirements before being discharged to surface waterways. Treatment needs for pumped groundwater have not yet been determined and could include conditioning, flocculation, settlement/sedimentation, and/or processing at a package treatment plant. Velocity dissipation structures, such as rock or grouted riprap, will be used to prevent scour where treated water is discharged back to the Delta. Location of dewatering discharge points will be determined at time of filing for coverage under the NPDES general permit or before start-up of discharge as appropriate. Additional information will be developed during design and the contractor will be required to comply with permit requirements.

Dredging and Riprap Placement

For the purposes of this consultation, dredging and riprap placement are defined to be activities that occur in fish-bearing waters. This definition thus excludes, for instance, dredging that occurs in the sedimentation basins at the intakes, or riprap placement that occurs in a dewatered area. Dredging is subject to constraints imposed by the Federal permit for the activity. Riprap placement would also comply with relevant NPDES and SWRCB requirements; and with the proposed in-water work windows.

Barge Landing Construction and Barge Traffic

Contractors will use barges to deliver TBM components to TBM launch sites, and may also use barges to deliver other heavy or bulky equipment or materials to those sites, or to haul such materials from those sites. This activity will include the construction of barge landings, barge operations in the river, tug operations, and the eventual removal of the barge landings when construction is completed. Barge landings will be needed at these seven locations:

- Snodgrass Slough north of Twin Cities Road (adjacent to proposed IF)
- Little Potato Slough (Bouldin Island south)
- San Joaquin River (Venice Island south)
- San Joaquin River (Mandeville Island east at junction with Middle River)
- Middle River (Bacon Island north)
- Middle River (Victoria Island northwest)
- Old River (junction with West Canal at CCF)

Locations of the barge landings are shown in CWF BA Appendix 3.A, *Map Book for the Proposed Action*, CWF BA Chapter 6 page 6-22, and item no. 101 of the *BiOp Resolution Log* (CWF 2016). The *BiOp Resolution Log* also provides additional information related to barge traffic routes, including frequency and duration of travels. Locations are approximate; precise siting and dimensions of these docks are to be determined by DWR's construction contractors. To minimize potential effects to fish species, plans will be developed for materials that can be transported by truck or rail to launch and retrieval points along the proposed tunnel alignment. This includes investigating the potential of using rail to deliver materials and components to the Stockton and the CCF locations. See the CWF BA for further points characterizing the barge landings and barge uses.

Landscaping and Associated Activities

The construction phase at most conveyance facilities will conclude with landscaping. Revegetation of disturbed areas will be determined in accordance with guidance given by DWR's Water Resources Engineering Memorandum (WREM) Number (No.) 30a, Architectural Motif, State Water Project and through coordination with local agencies through an architectural review process. Landscaping in cleared areas will reuse topsoil stockpiled at the time of site